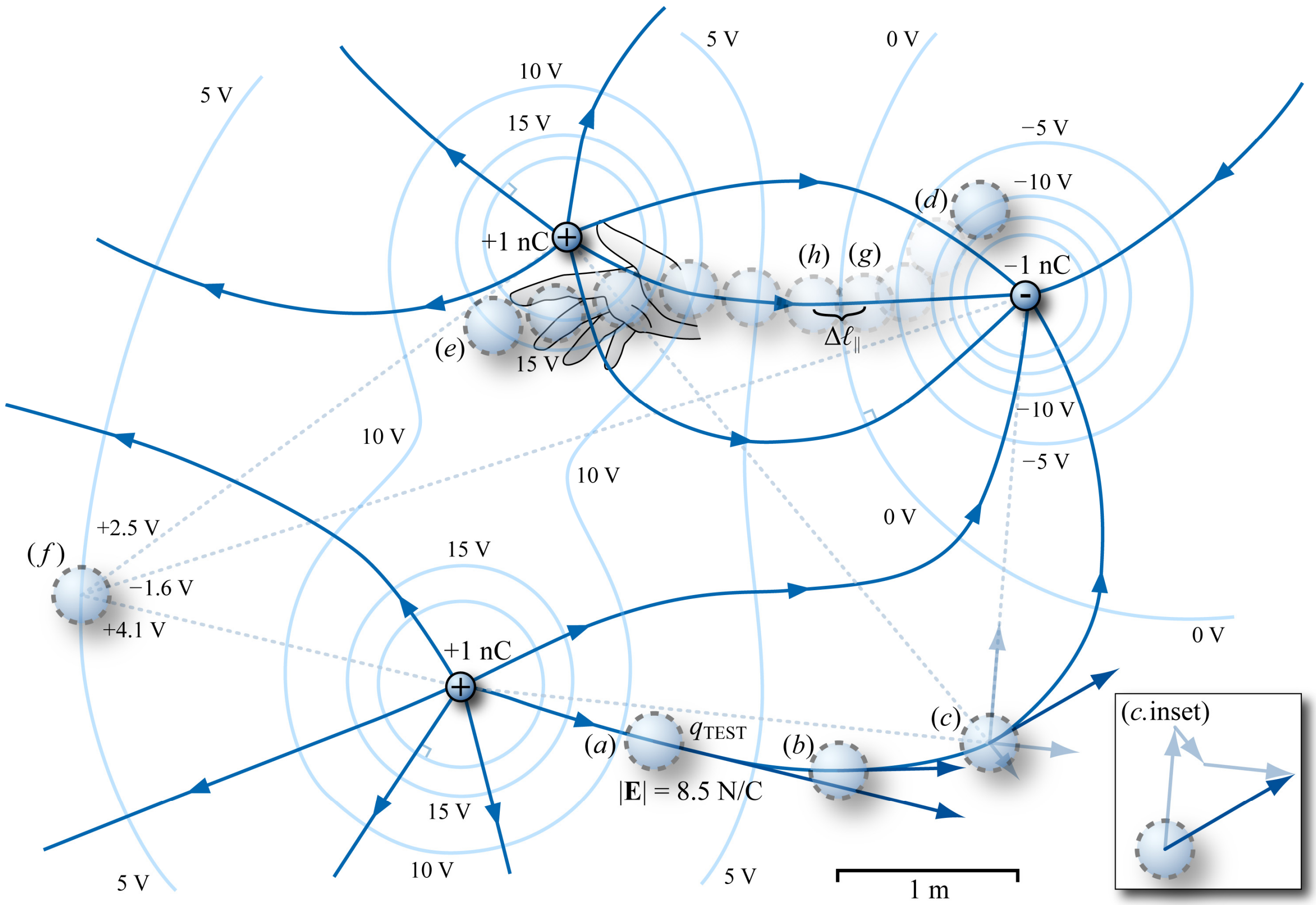
Electric fields and electric potentials

Charges create electric fields, and electric fields exert electric forces on charges.



Electric field

$$\vec{\mathbf{F}}_{\mathrm{E}} = q_{\mathrm{TEST}}\vec{\mathbf{E}} \qquad [E] = \frac{\mathrm{N}}{\mathrm{C}}$$

$$\left|\vec{\mathbf{E}}_{\mathrm{FROM\ POINT}}\right| = \frac{1}{4\pi\epsilon_0}\frac{|q_{\mathrm{POINT\ SRC}}|}{r^2}$$

$$\vec{\mathbf{E}} = \sum_i \vec{\mathbf{E}}_{\mathrm{FROM\ POINT},i}$$

Electric potential

$$\Delta W_{\mathrm{HAND}} = q_{\mathrm{TEST}}\Delta V \qquad [V] = \frac{\mathrm{J}}{\mathrm{C}}$$

$$\Delta U_{\mathrm{E}} = q_{\mathrm{TEST}}\Delta V \qquad [V] = \mathrm{V}$$

$$V_{\mathrm{FROM\ POINT}} = \frac{1}{4\pi\epsilon_0}\frac{q_{\mathrm{POINT\ SRC}}}{r}$$

$$V = \sum_i V_{\mathrm{FROM\ POINT},i}$$

Relating $\vec{\mathbf{E}}$ and V

When shoving test charge anti/parallel to electric force,

$$|\Delta W_{\mathrm{HAND}}| = \left|\vec{\mathbf{F}}_{\mathrm{AVG}}\right|\Delta\ell_{\parallel}$$

$$\cancel{|q_{\mathrm{TEST}}|}\,|\Delta V| = \cancel{|q_{\mathrm{TEST}}|}\left|\vec{\mathbf{E}}_{\mathrm{AVG}}\right|\Delta\ell_{\parallel}$$

$$\left|\vec{\mathbf{E}}_{\mathrm{AVG}}\right| = \frac{|\Delta V|}{\Delta\ell_{\parallel}}$$

($\vec{\mathbf{E}}$ points "downhill")

Electric field vector at a particular position $\vec{\mathbf{r}}$ points in the direction of the electric force that would be applied to a *positive* test charge. The magnitude of the electric field vector at $\vec{\mathbf{r}}$ is the strength of the electric force that would be exerted per each unit of test charge placed at $\vec{\mathbf{r}}$.

Potential difference between points (*a*) and (*b*) – amount of work that would be required of your hand per each unit of charge pushed from (*a*) to (*b*). Positive work by hand is required to move a *positive* test charge from a location with lesser potential to a location with greater potential.